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The Development and Evaluation of Advanced Rifle Marksmanship Training Programs with the M16 Rifle

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In May 1987 a research effort that examined current Advanced Rifle Marksmanship (ARM) training conducted during One Station Unit Training (OSUT) at Fort Benning, Georgia, was initiated. This research evaluated night fire with no illumination, normally scheduled night fire training with artificial illumination, and protective mask fire during daylight. Alternative methods of training were tested in addition to night fire training using the AN/PVS-4 night vision sight. Separate alternative training methods were tested for
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20. ABSTRACT (Continued)

protective mask fire during daylight. All training procedures developed during this effort used existing range facilities and training resources. Additional resource demands were confined to increases in training time allocation and extra ammunition. Findings indicated that soldiers had extreme difficulty in hitting targets during night fire with no illumination and with artificial illumination. Results for night fire using the AN/PVS-4 night vision sight showed that soldiers were capable of hitting targets out to 300 m. Findings for protective mask fire during daylight also indicated that soldiers were capable of hitting targets out to 300 m.

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Education and Training

FOREWORD

This report provides an evaluation of night fire under various conditions of illumination, night fire using an AN/PVS-4 night vision sight, and protective mask fire during daylight. The experimental rationale used in this research was based on evaluation of current Advanced Rifle Marksmanship (ARM) training for Infantry One Station Unit Training (OSUT) soldiers. The report outlines improvements to the current ARM program of instruction (POI) to increase training effectiveness with limited reallocation of existing resources and with minimal requirements for additional training time and ammunition. Recommendations for training standards for night fire with and without devices and for protective mask fire during daylight are described in the report with supporting rationale. Adoption of these recommendations would enhance training effectiveness and provide a quantifiable method of evaluating soldiers in these critical skills.

The research effort described in this report was monitored by ARI's Fort Benning Field Unit, whose mission is to conduct research and develop training and training technology using Infantry combat systems and problems as the vehicles. The major focus is on field experimentation within the Infantry arena with the goal of obtaining results that can be generalized to similar systems/problems in other segments of the Army or other services. Primary emphasis is in the areas of training systems/training technology, team training, and weapons systems training, all to improve the performance of soldiers and units. The research task supporting this mission is Developing Training for Individual and Crew-Served Weapons and is organized under the "Train the Force" program area. Providing sponsorship for the research effort was the United States Army Infantry School (USAIS) under letters of agreement, "Joint Efforts on Improved Training for Moving Target Engagement" and "Other Advanced Marksmanship Skills," dated 20 December 1984. Presentations were made to the USAIS in June 1987. It is expected that the research findings will be used to revise current training methods. Recommended revisions to training are expected to be implemented in the next ARM POI.

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AUTHOR NOTES

We gratefully acknowledge the assistance of Tommy R. Mueller and William J. Kyle in the data collection and of Dr. Jean Dyer, Arthur D. Osborne, and Louise S. Mullenix for comments on a draft of this report.

THE DEVELOPMENT AND EVALUATION OF ADVANCED RIFLE MARKSMANSHIP TRAINING PROGRAMS WITH THE M16 RIFLE

EXECUTIVE SUMMARY

Requirement:

To develop and evaluate Advanced Rifle Marksmanship (ARM) training programs for night fire and protective mask fire.

Procedure:

Program efforts using existing resources involved revising current training methods to improve night fire and protective mask fire performance. Infantry One Station Unit Training (OSUT) soldiers were selected from multiple companies to serve as test personnel and were assigned to separate treatment groups. Equal distribution of marksmanship skills between treatment groups was determined by Basic Rifle Marksmanship (BRM) qualification scores. Baseline data were collected on separate companies before each test was conducted. Then data were used as guidelines for the experimental procedures for the test companies. One treatment group received the current period of instruction for night fire or protective mask fire; the other treatment group received revised training procedures with existing training resources or revised training procedures with special training devices. All live firing was conducted on a field fire range or a down range feedback range equipped with a location of miss and hit (LOMAH) capability. Ammunition requirements for night fire varied according to the testing procedure being employed.

Findings:

Soldiers in the treatment groups that received modified training for night fire with no illumination and night fire with artificial illumination hit significantly more targets than soldiers who received normally scheduled training. However, these results are misleading, since target hit probability at all ranges was never greater than .31 for any treatment group. It is recommended that an area target be used for night fire under such conditions rather than single target exposures of E-type silhouettes. Results for night fire using the AN/PVS-4 night vision sight indicated that even with minimal training, soldiers were capable of hitting targets out to 300 m. Similar findings were obtained for protective mask fire during daylight.

Utilization of Findings:

The U.S. Army Infantry School (USAIS) has been briefed on the findings of this research and it is expected that the recommended revisions will be implemented within the ARM Program of Instruction. In addition, it is expected that the research findings for night fire and protective mask fire will be used by Army decision-makers to determine the future training priority of these important combat skills.

THE DEVELOPMENT AND EVALUATION OF ADVANCED RIFLE MARKSMANSHIP TRAINING PROGRAMS WITH THE M16 RIFLE

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THE DEVELOPMENT AND EVALUATION OF ADVANCED RIFLE MARKSMANSHIP TRAINING PROGRAMS WITH THE M16 RIFLE

INTRODUCTION

In 1982 an evaluation of the advanced rifle marksmanship (ARM) program of instruction (POI) for Infantry one station unit training (OSUT) was conducted. The existing POI was found to have three major problems: (1) limited scope of training, (2) inappropriate automatic fire and night fire training, and (3) inadequate feedback on bullet location (Evans & Schendel, 1984). Based on these findings a revised POI was implemented, without formal evaluation, in May 1982 at Fort Benning, Georgia.

A more recent research effort of the current ARM POI was initiated in 1985 by the U.S. Army Research Institute Field Unit at Fort Benning, Georgia and its resident contractor, Litton Computer Services. Initial evaluation of ARM skills focused on moving target engagement and evaluated the current ARM moving target POI in terms of training and cost effectiveness (Hunt, Parish, Martere, Osborne, & Evans, in press-a; Hunt, Parish, Martere, & Evans, in press-b). The experiments described in the current report concentrated on night fire under various conditions of illumination, night fire using night vision devices, and protective mask fire during daylight.

The experiments evaluated current training and determined appropriate training techniques and performance standards for each POI. The training conditions examined were based upon a prioritized list of critical ARM skills determined by the Directorate of Training and Doctrine (DOTD) in the U.S. Army Infantry School (USAIS). The critical ARM skills identified were: (1) night fire with no illumination where target acquisition is achieved through muzzle flash simulators, (2) night fire with artificial illumination to simulate ground or air flares, (3) night fire using night vision devices, and (4) protective mask fire during daylight.

Of the four skills being evaluated, only night fire with artificial illumination and protective mask fire were being taught in ARM. Training for night fire with artificial illumination required soldiers to engage 30 single target exposures of an E-type silhouette target at 75 m from the prone bipod supported firing position. Targets were illuminated by stadium lights to simulate ground/air flares. The level of illumination was controlled by a rheostat and varied during the course of fire. Soldiers were given two 15 round magazines of M193 5.56 mm ammunition and were allowed a total of 90 s to engage the 30 target exposures. Performance standards were 15 targets hit out of 30 exposures; however, soldiers received no feedback after completing the course of fire and the number of targets hit was not recorded. Protective mask fire was conducted in conjunction with automatic fire and required soldiers to wear a M19A1 protective mask while engaging a pop-up F-type target at 75 m with 15 rounds of automatic fire. Soldiers that wore glasses did not participate in training because they did not have their protective mask inserts present during training. Feedback was minimized to the soldier counting the number of times

the target fell and returned to an upright position. No formal presentation of a soldier's performance was provided and no performance standards were specified in the POI.

Observation of current instruction indicated several major problems: (1) current training did not follow the current POI, (2) soldiers did not receive performance feedback, and (3) performance standards specified in the POI were not enforced. Because there were no available performance data for the night fire and protective mask fire being evaluated in this research effort, it was necessary to collect pilot data to establish performance standards and to evaluate the training procedure being utilized. If the pilot study revealed a methodological flaw in the training, appropriate modifications were made prior to conducting the experiment.

The main purpose of this research effort was to determine the best training techniques and appropriate performance standards for night fire under various conditions of illumination and for protective mask fire during daylight. This research effort utilized two separate experimental procedures, one using the existing field POI and range facilities, and the other with a modified POI and existing range facilities. Pilot data were collected for all experiments using existing ARM POI's; however, slight modifications were necessary to allow collection of baseline performance data. For example, ranges in the live-fire scenarios were compatible with the LOMAH range configuration (see Hunt et al., in press-a, for a detailed description of a LOMAH target system). These modifications did not require any training reorganization and were confined to procedural changes for the live fire portion of training. Subsequent changes in experimental procedures were based on the findings of pilot data. These changes were defined by restructuring the training methodology, using special devices, and the development of new live-fire scenarios.

A series of five experiments was used for evaluation of four night fire POI's with and without night vision devices, and for protective mask fire during daylight. All experiments were conducted on a field fire range and a down range feedback range equipped with a LOMAH capability with targets at 75, 175, and 300 m. The results of these experiments were used to develop a training support package outlining training procedures and performance standards for both night fire and protective mask fire (Martere, Hunt, Lucariello, & Parish, in preparation).

EXPERIMENT 1: NIGHT FIRE WITH MUZZLE FLASH SIMULATOR

The purpose of this experiment was to compare various training techniques for engaging targets using a muzzle flash simulator as the only means of target detection. These data were used to determine appropriate training techniques and performance standards for night fire conducted under such conditions. Prior to conducting the experiment, a study was conducted to collect baseline data for night fire with a muzzle flash simulator. The soldiers used in the study received the current ARM POI for night fire with the exception that the procedures for live fire were modified to allow performance data to be collected for targets at both 75 and 175 m.

Method

Subjects

Baseline data were collected on a company of Infantry OSUT soldiers (*N* = 82) scheduled to receive night fire training. Fifty soldiers from a second Infantry OSUT company were used as test subjects. Half was assigned to one treatment group and the other half was assigned to a second treatment group. Each group consisted of the same number of experts, sharpshooters, and marksmen based on their Basic Rifle Marksmanship (BRM) qualification scores.

Equipment

All testing was conducted with unit allocated ammunition and range facilities with a LOMAH capability. Each target was equipped with a lighting mechanism (NSN 6220-00-577-3435) wired to a 12 V flasher unit connected to the terminals of the M31A1 target mechanism. Each time the target was raised the light was illuminated and continued to flash at a periodic rate of one second while the target remained in an upright position. The lighting mechanism was centrally located on the T-bar of the LOMAH equipment at the base of the E-type silhouette and inclined at an angle of approximately 45° to the target. This configuration allowed a four inch square of reflective tape, centrally located 16 inches below the top of the target, to be illuminated simultaneously with the lighting mechanism. This device was used to simulate the muzzle flash of return fire. Soldiers engaged all courses of fire in a prone supported firing position using their service rifle mounted on an M3 bipod. Each soldier was provided with two 15 round magazines of M193 ammunition.

Procedure

Soldiers in the company used to collect baseline data were briefed by range cadre. Soldiers received current training except they were required to engage 15 single target exposures of an E-type target at 175 m and 15 single target exposures of an E-type target at 75 m (current training requires soldiers to engage 30 single target exposures of an E-type target at 75 m using the over the sight pointing technique described in FC 23-11, p. 24-4). Target presentation at these ranges was counterbalanced across firing orders. Soldiers were allowed a total of 90 s, 45 s at each target range, to engage the

30 target exposures. Soldiers with weapon and/or ammunition malfunctions fired alibi rounds after completion of fire at each target range. A printout of shot location for each round, including targets hit, at both ranges was printed by the computer located in the range control tower after each firing order completed the course of fire.

Separate training techniques for night fire with a muzzle flash simulator were evaluated using a second OSUT company. Group 1 (without tracer, $n = 25$) received current training with the exception that soldiers were required to engage 15 single target exposures at both 75 and 175 m. Group 2 (with tracer, $n = 25$) received the same training as Group 1, with the exception that each soldier received 10 rounds of M196 tracer ammunition loaded in a 1:2 ratio with 20 rounds of M193 5.56 mm ball ammunition. All experimental procedures were identical to those described for the baseline company. Shot location for each round and total targets hit for each soldier were collected for each treatment group. LOMAH data were evaluated for each group to determine the feasibility of designating an area of fire as a night fire standard on a LOMAH equipped range rather than a specific number of targets hit.

Results

The descriptive statistics computed for the baseline company showed that 27 soldiers hit one or more targets at 75 m ($M = .88$, $SD = 1.82$) and 18 soldiers hit one or more targets at 175 m ($M = .28$, $SD = .59$). The Pearson product-moment correlations between BRM qualification scores and scores obtained during night fire at both target ranges were not significant. Similarly, there was no correlation between night fire scores for 75 and 175 m.

A 2 (Group) x 2 (Target Range) analysis of variance (ANOVA) with repeated measures on the second factor was used for analysis of the test company data. The Group x Target Range interaction was significant, $F(1,48) = 6.93$, $p < .01$ (Figure 1). A Tukey post hoc analysis showed that Group 2 had significantly more targets hit at 75 m ($M = 2.96$) than Group 1 ($M = 1.0$), $t(48) = 4.56$, $p < .05$. The difference between targets hit for Group 1 ($M = .16$) and Group 2 ($M = .52$) at 175 m was not significant. The Pearson product-moment correlations between BRM qualification scores and scores obtained during night fire at both target ranges were not significant. Similarly, there was no correlation between night fire scores for 75 and 175 m.

The post hoc analyses of shot location data collected for each treatment group are shown in Tables 1 and 2. Both tables show the extreme horizontal spread (X readings) and the extreme vertical spread (Y readings) of the shot location data. Negative numbers indicate shots to the left and below target center and positive numbers indicate shots to the right and above target center. These data were based on the total number of rounds recorded at each range (47% at 75 m, and 24.9% at 175 m for Table 1; 78.8% at 75 m, and 35.3% at 175 m). Thus, for the baseline company 53% of the rounds at 75 m and 75.1% of the rounds at 175 m were outside of the LOMAH detection area (a 4 m window either side of and above target center). For the test company 21.2% of rounds at 75 m and 64.7% of rounds at 175 m were outside of the LOMAH detection area.

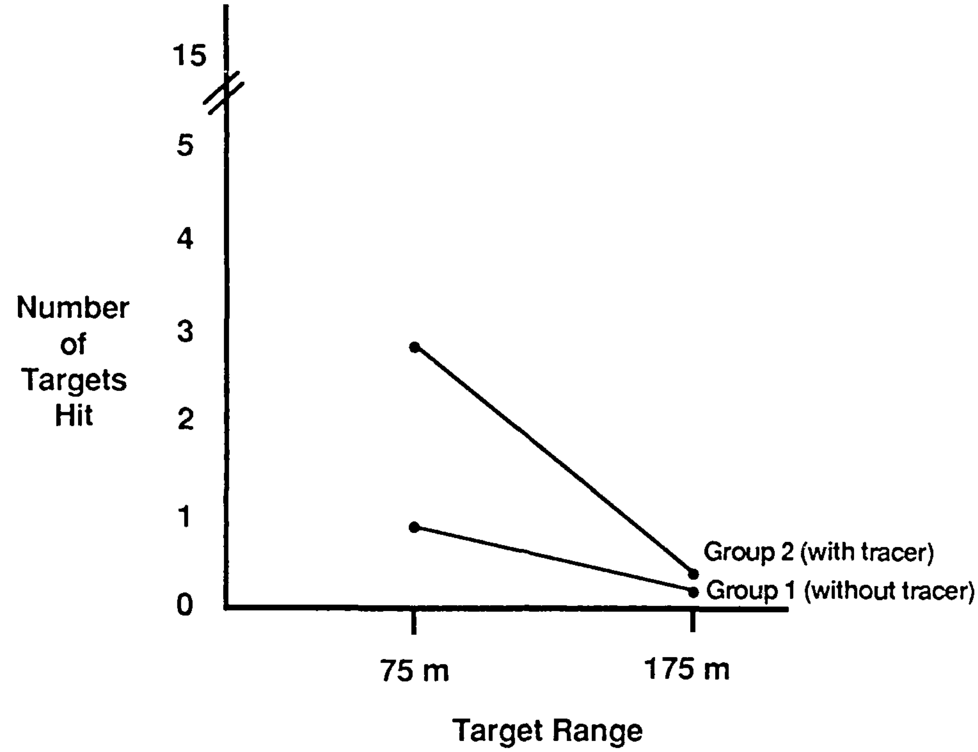

Figure 1. Mean number of targets hit for each group for night fire with the muzzle flash simulator.

Table 1

Extreme Spread of Shot Location Data for the Baseline Company

Target Range		Extreme Spread of Shot Location Data	
		5%	95%
75 m	X	-40.90 in	+53.08 in
	Y	-12.47 in	+73.90 in
175 m	X	-53.48 in	+59.72 in
	Y	-15.04 in	+79.23 in

Table 2

Extreme Spread of Shot Location Data for the Test Company

Target Range		Extreme Spread of Shot Location Data 5%	95%
75 m	X	-37.34 in	+40.99 in
	Y	-12.85 in	+77.08 in
175 m	X	-70.59 in	+52.63 in
	Y	-11.08 in	+80.06 in

Discussion

The results show that only 6% of target exposures at 75 m and 2% of target exposures at 175 m were hit using the muzzle flash simulator lighting mechanism as the only means of target detection. Observations by research personnel indicated that soldiers had extreme difficulty in establishing and maintaining a target/weapon relationship that allowed them to engage targets successfully. This poor target/weapon relationship resulted in many rounds being fired short of the target or outside of the LOMAH detection area. These observations are supported by the shot dispersion data presented in Tables 1 and 2. Subsequent posttest interviews with the soldiers in the baseline company verified the observations made by research personnel during testing. The inability to establish an adequate target/weapon relationship precludes the soldier from engaging targets with any degree of accuracy and confidence because target engagement is, through necessity, by trial and error under these conditions. The data indicate that requiring soldiers to engage a point target at these ranges under such lighting conditions at night is unrealistic.

The results for Group 1 in the test company paralleled the results obtained for the baseline company. The results for Group 2 showed the use of tracer ammunition resulted in a moderate increase in the number of targets hit at 75 m (approximately 20%). Overall, the results for both companies used in this experiment indicate that establishing a night fire standard based on a specific number of targets hit for this course of fire is an unrealistic goal.

A possible solution is to require soldiers to fire a designated number of rounds into a predetermined area of fire surrounding the target. The rationale underlying this suggestion is that ability to perform this task provides effective suppressive fire and increases the probability of obtaining target hits. The data indicate that this standard should only be established for targets at 75 m and less. The reason for this is that only 25% of the rounds

fired at 175 m were accounted for during collection of the baseline data. Thus, 75% of the rounds fired at this range were either short of the target or outside of the detection area of LOMAH. The LOMAH data indicate that the area of fire should be 2.44 m wide by 1.52 m high surrounding the target (see Figure 2). These figures are based on the shot location data obtained for the baseline and test companies. The horizontal dimension of the area of fire is based on the mean of the 95th percentile of the X readings for the baseline and test companies, and the vertical dimension is based on the mean of the 50th percentile of the Y readings for the baseline and test companies. The rationale to support the use of different percentile data for the horizontal and vertical dimensions of the area of fire is based on tactical considerations. More specifically, the majority of combat rifle fire is suppressive type fire where the soldier is not engaging a definite target. The conditions reported in this experiment indicate the difficulty soldiers encountered trying to engage a specific target and suggest that ability to provide effective suppressive fire may be an extremely important skill in such conditions. The ability to place a large volume of accurate fire in locations around the enemy will keep the enemy's head down, reduce the capability of return fire, and allow friendly forces freedom of movement (FC 23-11, p.27-1).

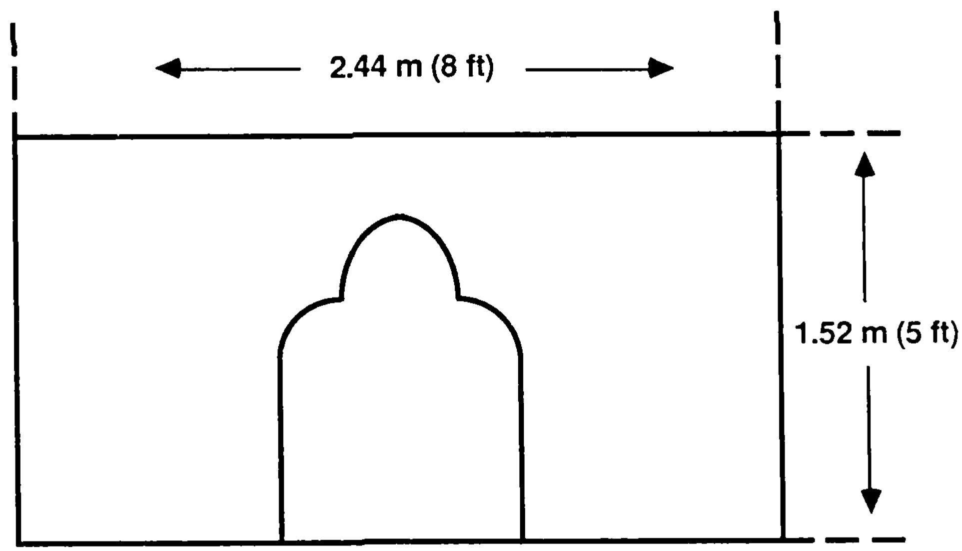

Figure 2. Suggested area of fire for night fire with artificial illumination.

EXPERIMENT 2: NIGHT FIRE WITH ARTIFICIAL ILLUMINATION

The purpose of this experiment was to compare various training techniques for engaging targets under artificial illumination. This comparison was used to determine appropriate night fire standards and the best training techniques for firing under these conditions. Prior to conducting this experiment, current training was evaluated and used to collect pilot data for night fire with artificial illumination. These data were used to determine any changes in training methodology to be implemented in the experiment.

Method

Subjects

Fifty one OSUT soldiers scheduled to receive night fire training were used to collect pilot data. Thirty four soldiers from a second OSUT company scheduled to receive the same night fire training were used to compare alternate training techniques. The 34 soldiers from the second company were divided into two equal groups (n = 17). Each group consisted of the same number of experts, sharpshooters, and marksmen based on their BRM Qualification scores.

Equipment

Testing was conducted with unit allocated ammunition and range facilities. All testing was conducted on a field fire range equipped with stadium lights to simulate illumination flares. The range was comprised of pop-up E-type silhouette targets at 75 and 175 m. Paper facings (NSN 6920-00-600-6874) were placed on each target before each firing order engaged the course of fire. These were used to count targets hit in the absence of LOMAH and Remoted Target System (RETS) capabilities. Soldiers in the baseline company and Group 1 of the test company fired the M16A1 rifle with M193 ammunition, and Group 2 of the test company used issued M16A2 rifles with M855 ammunition. Both groups used their rifles mounted on M3 bipods.

Procedure

Soldiers in the company used to collect pilot data were briefed by range cadre. All training was identical to current training (30 single target exposures of an E-type target at 75 m) except that soldiers were required to engage a total of 30 single target exposures of an E-type target, 15 at 75 m and 15 at 175 m, with 30 rounds of ammunition. Soldiers were allowed 45 s at each target range to engage the targets. Soldiers with weapon and/or ammunition malfunctions fired alibi rounds after completion of fire at each target range. These data allowed research personnel to determine if the over-the-sight pointing technique currently taught for night fire target engagement was appropriate at ranges beyond 75 m under artificial illumination conditions. Soldiers engaged the 15 target exposures at each target range from a prone bipod supported position.

Two training techniques for night fire with artificial illumination were evaluated using the soldiers from the second OSUT company. All groups engaged a total of 30 single target exposures with 30 rounds of ammunition at 75 and 175 m (15 target exposures at each range). Group 1 (n = 17) received current training and used the over-the-sight pointing technique with the M16A1 rifle to engage targets (FC 23-11, p.24-4). Group 2 (n = 17) received modified training to teach through-the-sight aiming using the 5 mm rear sight aperture of the M16A2 standard sight (soldiers in Group 2 zeroed their issued M16A2 prior to firing night fire). Soldiers in both groups engaged the 15 target exposures at each target range from a prone bipod supported position.

Results

The descriptive statistics for the baseline company indicated more targets were hit at 75 m (M = 2.51, SD = 3.21) than at 175 m (M = .67, SD = 1.24). The Pearson product-moment correlations between BRM qualification and night fire scores for 75 and 175 m were not significant. Similarly, the correlation between night fire scores was not significant.

A 2 (Group) x 2 (Target Range) ANOVA with repeated measures on the second factor was used for analysis of the test company. The main effect of group, $F(1,32) = 19.69$, $p < .001$, was significant. Group 2 had significantly more targets hit (M = 4.5) than Group 1 (M = 1.33). Inspection of the means for both treatment groups showed that soldiers in Group 2 had approximately the same number of targets hit at 75 m (M = 4.71) and 175 m (M = 4.29), whereas soldiers in Group 1 hit more targets at 75 m (M = 2.35) than at 175 m (M = .29). The Pearson product-moment correlations between BRM qualification scores and scores obtained during night fire at both target ranges were not significant. Similarly, there was no correlation between night fire scores for 75 and 175 m.

Discussion

The results of the pilot study show that only 17% of target exposures at 75 m and 5% of target exposures at 175 m were hit. As with Experiment 1, soldiers encountered similar problems in establishing and maintaining a target/weapon relationship that allowed them to engage the target successfully. The observations made by research personnel were verified with posttest interviews with the soldiers. Overall, the results obtained for the pilot study paralleled those obtained in Experiment 1 and, again, indicated the problems of engaging targets at night using an over-the-sight pointing technique.

The results for the test company indicate that soldiers in Group 2, who used a through-the-sight aiming technique, achieved approximately the same number of targets hit at both 75 and 175 m. These data show the superiority of through-the-sight aiming compared with the over-the-sight pointing technique. While soldiers in Group 2 (31%) hit twice as many targets as soldiers in Group 1 (16%) at 75 m, the percentage of targets hit was still lower than the night

fire standard in the current ARM POI of 50% targets hit under artificial illumination. However, hit probability at 175 m for Group 2 was .29, .02 less than at 75 m, whereas hit probability at 175 m for Group 1 was only .02. The comparable performance of Group 2 at both 75 and 175 m explains why there was no main effect for target range in this experiment. Clearly the results demonstrate that through-the-sight aiming with the 5 mm aperture on the M16A2 rear sight is preferable to the over-the-sight pointing technique for night fire under these conditions. Posttest interviews with soldiers in Group 1 supported previous observations that it was difficult to establish and maintain a target/weapon relationship that allowed successful engagement of targets. Conversely soldiers in Group 2 reported that it was easy to obtain a good sight picture on targets at 75 and 175 m, and they were confident in their ability to hit targets at night under these conditions.

EXPERIMENT 3: NIGHT FIRE WITH ARTIFICIAL ILLUMINATION AND A MUZZLE FLASH SIMULATOR

The results from the first two experiments demonstrated the difficulty of engaging targets at night with a muzzle flash simulator and with artificial illumination. The following experiment was conducted to see if a combination of artificial illumination and simulated return enemy fire aided target detection and improved hit probability during night fire.

The purpose of the experiment was to evaluate a transitional training program where soldiers fired during daylight and at night using the same over-the-sight pointing technique of engaging targets. In addition, one treatment group received LOMAH feedback for two of the three firing iterations during the experiment to evaluate the effects of providing performance feedback on subsequent target engagement.

Method

Subjects

Forty subjects from a company of OSUT soldiers scheduled for night fire training were used in this experiment. Half of the subjects were assigned to one treatment group and the other half were assigned to a second treatment group. Each group consisted of the same number of experts, sharpshooters, and marksmen based on their BRM qualification score.

Equipment

All testing was conducted with unit allocated ammunition and performed on a range with a LOMAH capability. Soldiers in one group received modified night fire training without the LOMAH equipment, the other group was trained using the LOMAH equipment. Targets were equipped with the same lighting mechanism described in Experiment 1 to simulate return enemy fire. In addition, the targets were illuminated using 150 W spotlights mounted on eight foot posts located approximately 10 m behind the 75 m targets down range. The two posts,

each with three spotlights, were located at the extreme left and right sides of the sector of fire. The spotlights were powered by a Honda 2200 W commercial generator (Model No. 2200) and the level of brightness of the lights was controlled using a rheostat. This lighting system allowed targets at 75 m to be illuminated from the rear and targets at 175 m to be illuminated from the front. This configuration was used to simulate illumination flares in addition to the lighting system used to simulate return enemy fire. All firing was conducted with M16A1 rifles mounted on M3 bipods.

Procedure

All instruction was given by research personnel. Group 1 ($n = 20$) was taught the over-the-sight pointing technique of engaging targets. Group 2 ($n = 20$) was taught the same technique for engaging targets and received shot location feedback from the LOMAH system after each round was fired. All soldiers fired a total of 60 rounds of M193 ammunition (20 rounds during daylight, and 40 rounds at night). All firing was conducted in three 20 round iterations with 10 rounds fired at 75 m and 10 rounds at 175 m. All soldiers were allowed 30 s to engage 10 target exposures at each target range. During night fire the level of illumination of the spotlights was controlled using a rheostat. From 0-10 s of the scenario, the level of illumination was changed from darkness to maximum intensity, from 10-20 s the level of illumination remained at full intensity, and from 20-30 s the level of illumination decreased from maximum intensity to darkness.

Group 1 fired all three iterations (one iteration during daylight and two iterations at night) without LOMAH feedback. Group 2 fired the first two iterations with LOMAH feedback and the third iteration without LOMAH feedback. The LOMAH feedback gave soldiers a visual representation of the exact location of each round fired within the detection area of the equipment. Each shot was shown as an illuminated dot on the visual display monitor located adjacent to the firing point. The most recent round in a shot group was denoted by a flashing dot. This feedback could be used by a soldier to make any necessary adjustments in his sight picture to enable him to hit the target. Group 2 fired the third iteration without LOMAH feedback to determine if limited exposure to feedback during the first two firing iterations affected subsequent performance without feedback. Soldiers with weapon and/or ammunition malfunctions fired alibi rounds after completion of fire at each target range. A printout of shot location for each round, including targets hit, at both ranges was printed by the computer located in the range control tower after each firing order completed the course of fire.

Results

A 2 (Group) x 3 (Firing Iteration) x 2 (Target Range) ANOVA with repeated measures on the second and third factors was used for analysis. The main effects for firing iteration, $F(2,76) = 11.91$, $p < .001$, and target range, $F(1,38) = 41.67$, $p < .001$, were both significant. The results showed that more targets were hit at 75 m ($M = 2.0$) than at 175 m ($M = .49$). A Tukey post hoc analysis showed that significantly more targets were hit during the daylight iteration ($M = 1.96$) than during either night fire iteration ($M = .96$ for the

second firing iteration and $M = .81$ for the third firing iteration). The difference between the means for targets hit during the two night fire iterations was not significant. The Pearson product-moment correlations between BRM qualification scores and scores obtained during night fire at both target ranges were not significant for either treatment group. However, the correlations between targets hit for the first and second firing iterations at 75 m for Group 1, $r = .43$, $p < .03$ and Group 2, $r = .50$ $p < .01$, were significant. Similarly, the correlations between 75 and 175 m for the second firing iteration were both significant (Group 1: $r = .41$, $p < .03$, Group 2: $r = .36$, $p < .05$). In addition, the correlation between targets hit at 75 and 175 m for the third firing iteration for Group 2, $r = .44$, $p < .03$, was significant.

Discussion

The results for night fire in this experiment paralleled those obtained for the baseline companies in Experiments 1 and 2. Although the result for daylight fire at 75 m was superior to both night fire iterations, the percentage of targets hit (19.6%) was still less than the current night fire standard of 50% targets hit. The low hit probability for daylight fire indicate the imprecise nature of the over-the-sight pointing technique for engaging targets at this range. This finding suggests that even in daylight conditions it is difficult for soldiers to establish and maintain a suitable target/weapon relationship that allows them to engage targets successfully. Furthermore, the absence of a significant group effect indicated that LOMAH feedback did not improve performance. This may be attributed to several factors: (1) the soldiers received limited exposure to this training device and used the feedback inappropriately, (2) soldiers only received 20 trials with LOMAH feedback during daylight and night fire, which may not have been enough to cause a significant group effect, and (3) the over-the-sight pointing technique is a trial and error method of engaging targets and the veridicality of providing feedback to such an imprecise skill is of questionable merit.

These data provide compelling evidence along with the data from the previous two experiments that the current standard for night fire under artificial illumination is unrealistic. These results lend further support to the suggestion of using a defined area of fire surrounding the target for night fire training rather than point targets.

The significant correlation between daylight fire and the first night fire iteration suggest that additional training in the over-the-sight pointing technique could be beneficial in transferring to night fire. A possible solution would be to reorganize the current POI and require soldiers to engage targets out to 75 m during quick fire training (which currently precedes night fire training under artificial illumination). If this modification was made, and an area of fire surrounding the target was used during both quick fire and night fire, it would increase the likelihood that soldiers would be capable of firing an acceptable percentage of rounds in the designated area of fire during night fire.

EXPERIMENT 4: NIGHT FIRE USING THE AN/PVS-4 NIGHT VISION SIGHT

The first three experiments in this research effort indicated that requiring soldiers to engage point targets at night under various levels of illumination without the aid of a night vision device was unrealistic. The next experiment was conducted to determine the effectiveness of the AN/PVS-4 night vision sight in improving night fire performance.

The purpose of this experiment was to develop a POI using the AN/PVS-4 night vision sight for night fire training. The development of the POI was based on pilot data collected on a LOMAH range with targets from 75-300 m for soldiers using the AN/PVS-4 night vision sight.

Method

Subjects

Forty two soldiers in an OSUT company undergoing ARM training at Fort Benning, Georgia were used to collect the baseline data. Half of the soldiers was assigned to one treatment group and the other half was assigned to a second treatment group. Forty soldiers from a second OSUT company were used to determine the effectiveness of the test POI and to establish night fire standards for this course of fire. Half of the soldiers in the second company was assigned to one treatment group and the other half was assigned to a second treatment group. Each group consisted of the same number of experts, sharpshooters, and marksmen based on their BRM qualification score.

Equipment

All testing was performed on a LOMAH range. Ten AN/PVS-4 night vision sights were available to research personnel for testing. The same lighting mechanism described in Experiment 1 was used to simulate return enemy fire for one group in both the baseline and test companies. Pop-up F-type silhouette targets were used at 75 m and pop-up E-type silhouette targets were used at 175 and 300 m. Soldiers used their issued M16A1 rifles to zero the AN/PVS-4 night vision sights.

Procedure

All soldiers in the pilot study were instructed by research personnel on how to mount and place the AN/PVS-4 into operation. Six expert BRM qualified soldiers zeroed the night vision sights to their issued M16A1 during daylight. After completion of this exercise, the AN/PVS-4's remained mounted on the weapons until all soldiers in the study had fired the daylight and night fire courses of fire. All soldiers were required to engage a total of 30 target exposures at 75, 175, and 300 m (10 target exposures at each range) during daylight with 30 rounds of ammunition. The presentation of targets was counterbalanced across firing orders. For night fire, soldiers engaged an additional 30 target exposures, 10 target exposures at each range, at 75, 175,

and 300 m. Soldiers in both groups were allowed 30 s to engage 10 target exposures with 10 rounds of ammunition at each range. Group 1 ($n = 21$) fired at targets that were illuminated by the muzzle flash simulator described in Experiment 1, Group 2 ($n = 21$) fired at targets with no illumination. These data were used as baseline data for night fire using the AN/PVS-4 night vision sight and comparisons were made between daylight and night fire scores. Soldiers with weapon and/or ammunition malfunctions fired alibi rounds after completion of fire at each target range. A printout of shot location for each round, including targets hit, at both ranges was printed by the computer located in the range control tower after each firing order completed the course of fire.

Seven expert BRM qualified soldiers from the test group zeroed the night vision sights to their issued M16A1 during daylight. As with the pilot study, AN/PVS-4's remained mounted on the weapons until all soldiers had completed testing. However, based on the results of the pilot study, the procedure for daylight fire for the test group was changed. Rather than firing a complete course of fire at 30 target exposures at ranges of 75, 175, and 300 m, after completion of zero, all soldiers fired five familiarization rounds at a 75 m target during daylight to ensure they understood the procedures for target engagement using the night vision sight reticle. This change was made because soldiers in the pilot study had reported difficulty in detecting targets at 175 and 300 m during daylight, which may have adversely affected their performance. The procedures for night fire and alibi firing were identical to that described for the pilot study.

Results

The comparison between daylight and night fire for the pilot study indicated moderately better scores for targets hit at all ranges for night fire. However, these differences were not statistically different.

The descriptive statistics for the baseline company showed that the number of targets hit at night decreased as target range increased ($M = 6.56$ for 75 m, $M = 3.42$ for 175 m, $M = 1.42$ for 300 m). A 2 (Group) x 3 (Target Range) ANOVA with repeated measures on the second factor was used to compare targets hit during night fire at each range. The Group x Target Range interaction was significant, $F(2,80) = 3.05$, $p < .05$ (Figure 3). A Tukey post hoc analysis showed that Group 1 ($M = 8.19$) had significantly more targets hit at 75 m than Group 2 ($M = 4.19$), $t(80) = 5.54$, $p < .01$. Similarly, the difference between targets hit at 175 m was significant (Group 1: $M = 4.76$, Group 2: $M = 1.38$), $t(80) = 4.68$, $p < .05$. The difference between targets hit at 300 m (Group 1: $M = 2.14$, Group 2: $M = .57$) was not significant. The Pearson product-moment correlation between BRM qualification scores and night fire scores with the AN/PVS-4 night vision sight was not significant. However, the correlation between night fire scores for targets hit at 175 and 300 m, $r = .60$, $p < .01$, was significant.

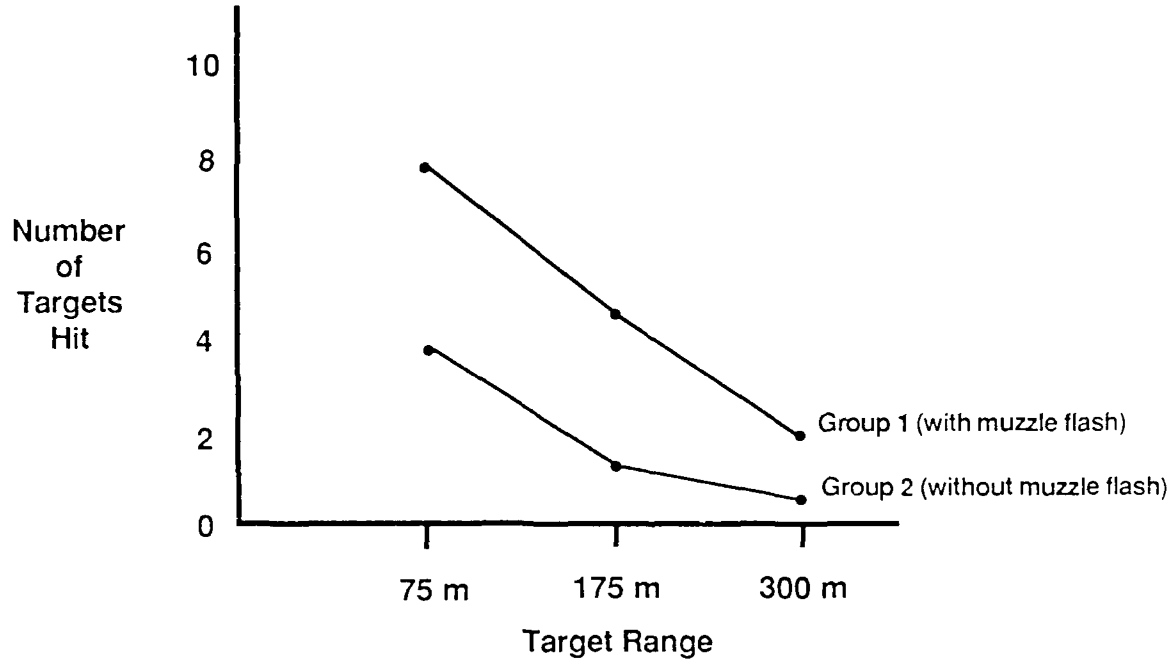

Figure 3. Mean number of targets hit for each group in the baseline company for night fire using the AN/PVS-4.

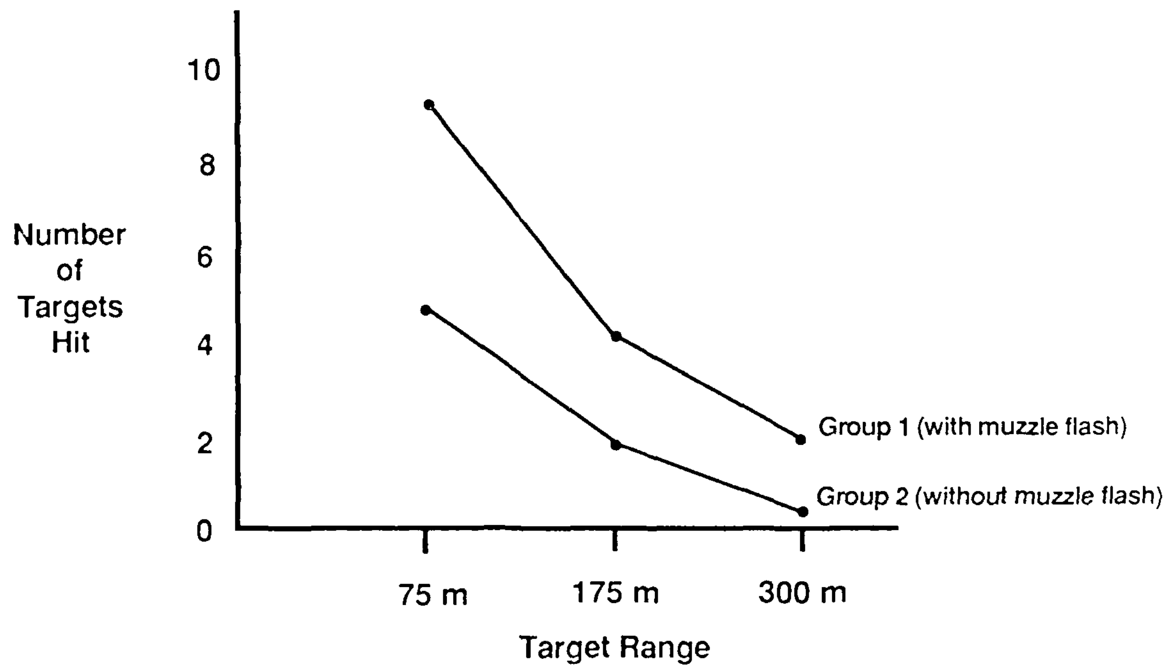

Figure 4. Mean number of targets hit for each group in the test company for night fire using the AN/PVS-4.

A 2 (Group) x 3 (Target Range) ANOVA with repeated measures on the second factor was used to compare targets hit during night fire at each range for the test company. The results paralleled those obtained for the baseline company. The Group x Target Range interaction, $F(2,76) = 4.77$, $p < .01$, was significant (Figure 4). A Tukey post hoc analysis showed that the difference between targets hit at 75 m for Group 1 ($M = 9.55$) and Group 2 ($M = 4.9$), $t(76) = 6.13$, $p < .01$, was significant. Similarly, the difference between targets hit at 175 m for Group 1 ($M = 4.35$) and Group 2 ($M = 2.05$), $t(76) = 3.03$, $p < .05$, was significant. The difference between targets hit at 300 m (Group 1: $M = 2.05$, Group 2: $M = 0.6$) was not significant.

The Pearson product-moment correlation between BRM qualification scores and night fire scores with the AN/PVS-4 night vision sight were not significant. However, the correlation between night fire scores for targets hit at 175 and 300 m, $r = .42$, $p < .01$, was significant.

Discussion

The results for both the pilot study and the follow-up experiment provide support for the utilization of the AN/PVS-4 night vision sight for night fire target engagement out to 300 m. The significant differences between the treatment groups in both experiments is the critical main effect for target range and can be explained by the difference in the target detection requirements of the two groups. Target detection problems for Group 1 in both experiments were reduced because the soldiers used the AN/PVS-4 night vision sight, and, in addition, all targets from 75-300 m were equipped with a lighting mechanism to simulate return enemy fire. Conversely, soldiers in Group 2 had to rely on their ability to detect targets with the AN/PVS-4. An important consideration is that testing of both companies was conducted in very poor conditions with low levels of ambient light. This factor may have had an adverse effect on target detection for soldiers in Group 2 for both experiments. It is recommended, therefore, that further testing be conducted in more favorable conditions. However, the results from this experiment compared with results from Experiments 1-3 clearly support the need for the use of a night vision device to engage point targets at night. In addition, an important procedural finding from this experiment was that soldiers in the test company, who fired five familiarization rounds during daylight, performed comparably during night fire to soldiers in the pilot study, who fired 30 rounds during daylight. This is an important finding in terms of cost and training effectiveness for night fire using the AN/PVS-4 night vision sight.

EXPERIMENT 5: PROTECTIVE MASK FIRE

The final experiment in this research effort examined the feasibility of engaging targets out to 300 m during daylight while wearing the M19A1 protective mask. Current training during ARM requires the soldier to engage a single E-type silhouette target at 75 m with automatic fire. The proposed program used targets from 75-300 m and semiautomatic fire.

The purpose of this experiment was to develop a protective mask fire POI using targets from 75-300 m and determine appropriate performance standards for the course of fire. The development of the POI was based on pilot data collected on a LOMAH range with targets from 75-300 m for protective mask fire.

Method

Subjects

Forty soldiers in an OSUT company undergoing ARM training at Fort Benning, Georgia were used to collect the pilot data. Sixty soldiers from a second OSUT company were used to establish protective mask fire standards for this course of fire. Soldiers in the test company were divided into three equal treatment groups (n = 20).

Equipment

Soldiers performed all firing on a LOMAH range with their service issued M16A1 rifle, M193 ball ammunition, and M19A1 protective mask. Soldiers that wore glasses used their protective mask inserts for all courses of fire. The range consisted of pop-up F-type targets at 75 m, and pop-up E-type targets at 175 and 300 m.

Procedure

Soldiers used for collection of pilot data received current training on how to engage targets with their rifle while wearing a protective mask with the exception that they fired a modified course of fire. They were required to engage a total of 45 single target exposures at 75, 175, and 300 m, 15 target exposures at each range, with semiautomatic fire. The standard course of fire requires soldiers to engage a single target exposure at 75 m with 15 rounds of ammunition. All soldiers performed the baseline test without LOMAH feedback. The first five rounds fired at each target range were treated as practice rounds, and the final 10 rounds at each range were used for baseline data. Soldiers were allowed 30 s to engage the final 10 target exposures; the five practice rounds were untimed. Soldiers with weapon and/or ammunition malfunctions fired alibi rounds after completion of fire at each target range. A printout of shot location for each round, including targets hit, at both ranges was printed by the computer located in the range control tower after each firing order completed the course of fire.

Soldiers from the second company were divided into three groups. Group 1 ($n = 20$) received identical training to that described for soldiers in the first company. Group 2 ($n = 20$) was briefed by research personnel on how to engage targets with their rifle while wearing a protective mask. Group 3 ($n = 20$) was briefed by research personnel on how to engage targets with their rifle while wearing a protective mask and on use of the LOMAH device. Soldiers in Groups 2 and 3 were given a graphic training aid to show the appropriate sight picture to engage targets at the three target ranges (see Figures 5 & 6). Soldiers in Group 3 used LOMAH during the five practice rounds to determine their sight picture for each target range. The final 10 rounds at each range were fired without the aid of LOMAH. All other test procedures were identical to those described for the baseline company.

Results

The descriptive statistics for the pilot data showed that the number of targets hit at 75 m ($M = 7.95$, $SD = 2.61$) was greater than the number of targets hit at 175 m ($M = 5.65$, $SD = 3.05$) and 300 m ($M = 2.06$, $SD = 2.12$). The Pearson product-moment correlation between BRM qualification scores and protective mask fire scores for 175 m was significant, $r = .38$, $p < .01$. In addition, the correlation between protective mask fire scores for 175 and 300 m was significant, $r = .48$, $p < .001$.

A 3 (Group) x 3 (Target Range) ANOVA with repeated measures on the second factor was used for analysis of the test data. The results indicated that the number of targets hit decreased as target range increased ($M = 9.38$ for 75 m, $M = 6.68$ for 175 m, $M = 2.43$ for 300 m). This accounted for the main effect of target range being significant, $F(2,114) = 219.71$, $p < .001$. In addition, the Group x Target Range interaction, $F(4,114) = 4.63$, $p < .01$, was significant and is shown in Figure 7. A Tukey post hoc test showed that the difference between targets hit at 175 m for Group 2 ($M = 7.55$) and Group 1 ($M = 5.25$), $t(114) = 3.97$, $p < .05$, was significant. Similarly, the difference between Group 3 ($M = 7.25$) and Group 1, $t(114) = 3.45$, $p < .05$, was significant. The difference between Groups 2 and 3 at 175 m was not significant. The differences between targets hit at 75 and 300 m between all three treatment groups were not significant. The Pearson product-moment correlation between BRM qualification scores and protective mask fire was not significant. However, the correlation between protective mask fire scores for targets hit at 175 and 300 m, $r = .32$, $p < .01$, was significant.

Discussion

The data for the baseline company were the first data in this research effort that provided a significant correlation for 175 m target presentations between BRM qualification scores and the ARM skill being tested. These data indicate a moderate positive correlation between the two scores such that a reasonable prediction of protective mask fire could be projected based on the soldier's BRM qualification score. These results are contrary to the data

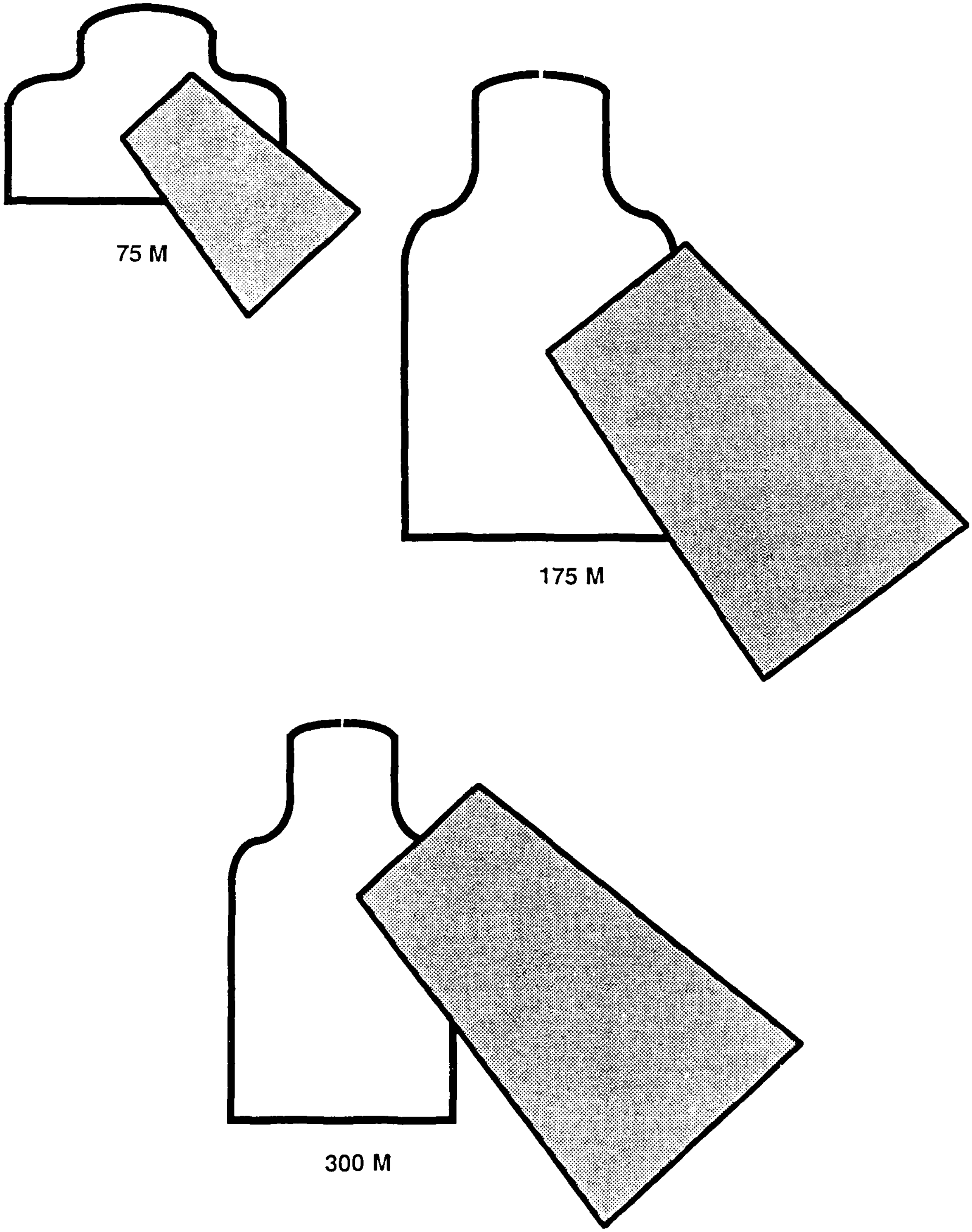

Figure 5. Theoretically correct aiming point (sight picture) for right-handed firers while wearing a protective mask.

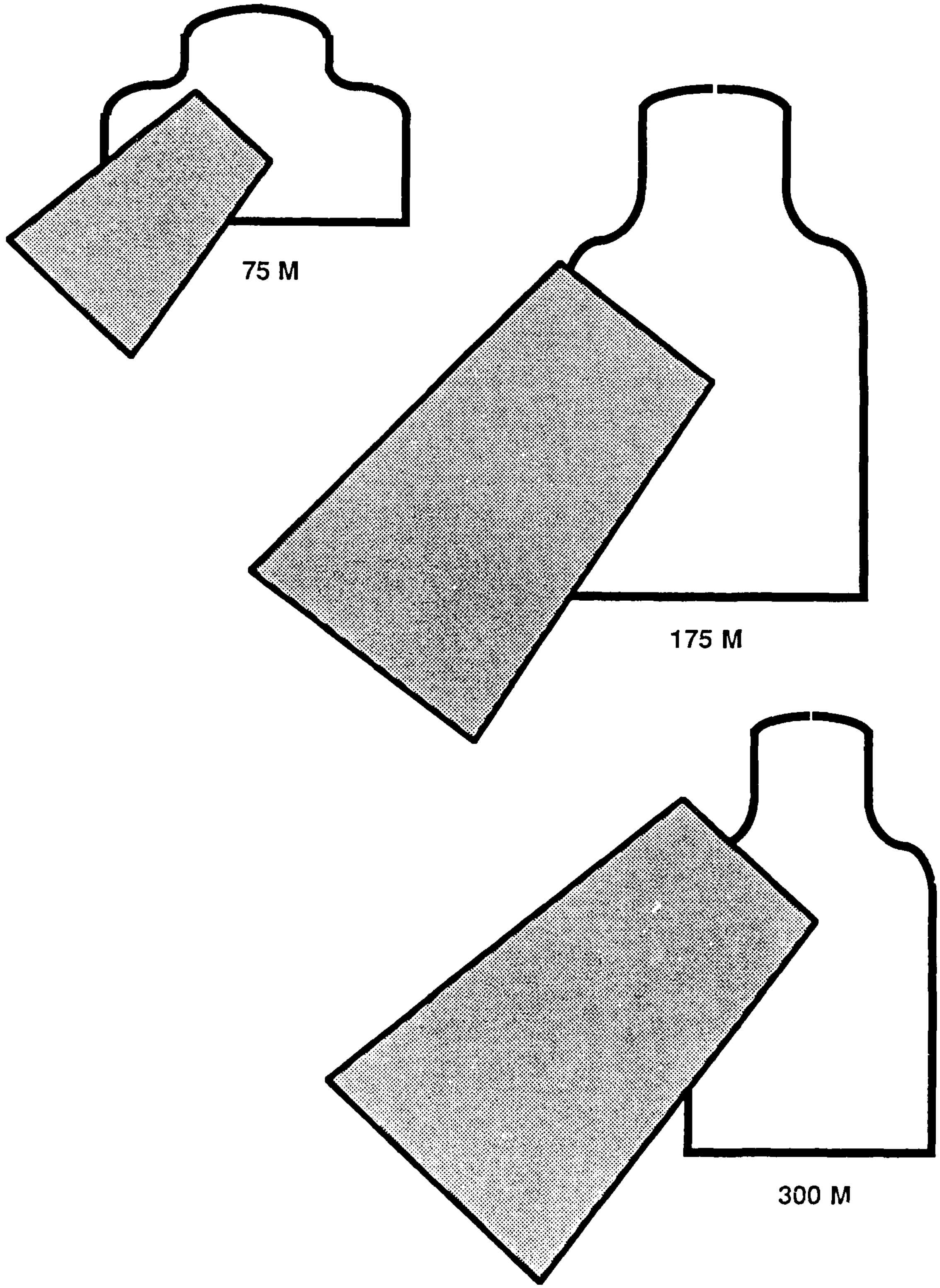

Figure 6. Theoretically correct aiming point (sight picture) for left-handed firers while wearing a protective mask.

collected for night fire in which the trial and error nature of firing at night described in Experiments 1-3 is so different from BRM that there is no correlation between the various courses of fire.

The data for the test company showed a significant difference in performance among the three test groups. The inclusion of the graphic training aid providing specific aiming points for each target range may account for the significant Group x Target Range interaction. The locus of this effect is confined to the difference between groups at 175 m where Groups 2 and 3 had 23 and 20% more targets hit than Group 1. There was no significant difference between targets hit for all three groups at 75 m because all groups scored close to the maximum at this range (see Figure 7). Conversely, performance at 300 m was consistently low for all groups and was not significant.

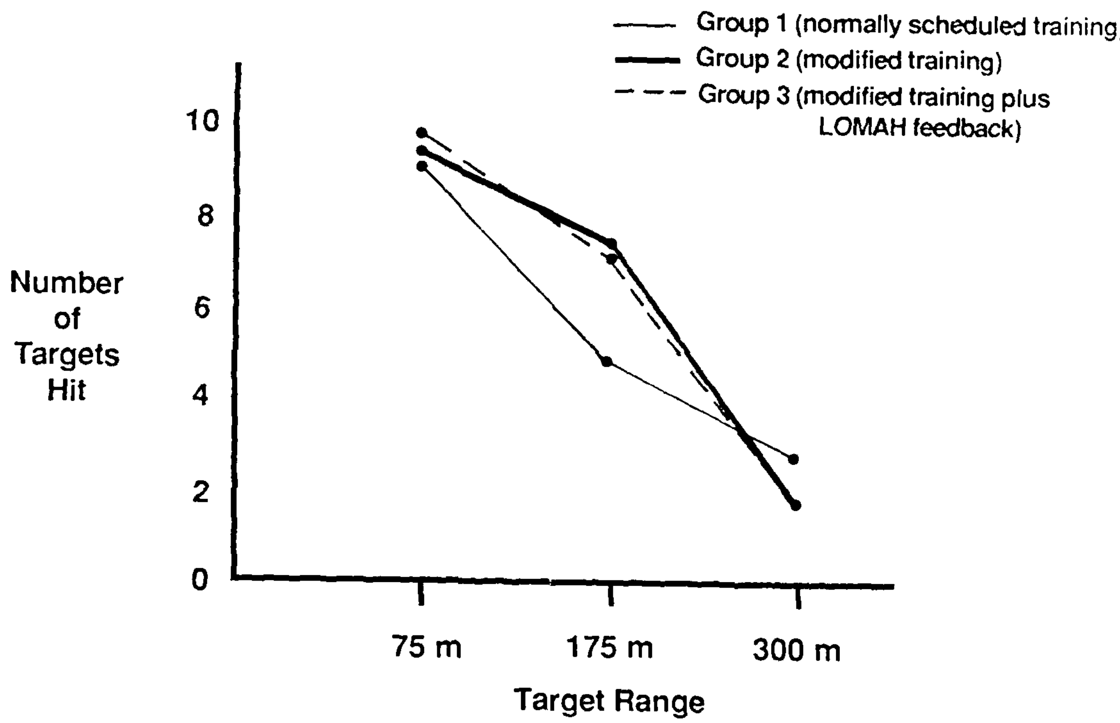

Figure 7. Mean number of targets hit for each group for protective mask fire.

These data suggest that the inclusion of a visual training aid showing soldiers appropriate sight pictures at each target range may be most beneficial at ranges beyond 75 m. At 75 m the strike of the round is not affected significantly and therefore, it would be expected that soldiers would perform well at this range. However, at ranges of 175 and 300 m where the bullet is expected to strike in the direction of the rifle cant (see FC 23-11 for a more detailed explanation), the use of a training aid which reduces the amount of experimentation in determining an appropriate sight picture would be predicted

to be more useful to the soldier. The data for this experiment provide support for this suggestion and indicate that soldiers wearing a protective mask performed comparably with soldiers during BRM record fire in terms of probability of targets hit at 175 and 300 m (Martere, Hunt & Parish, in press).

The data obtained for both the baseline and test companies indicate that soldiers can be expected to engage targets out to 300 m while wearing a protective mask. Current ARM training only requires the soldier to engage a single target at 75 m with 15 rounds of automatic fire. For soldiers to understand the effects of rifle cant on target engagement at ranges beyond 75 m, a course of fire that requires soldiers to engage targets beyond this range is essential.

GENERAL DISCUSSION

The purpose of this research effort was to develop and evaluate training programs for night fire that could be used to establish realistic performance standards for night fire under various conditions of illumination. In addition, a training program for protective mask fire during daylight was developed and evaluated. This program was used to establish performance standards for protective mask fire out to ranges of 300 m.

The results obtained for the experiments described in this report allow three major recommendations to be made: (a) night fire using the muzzle flash simulator and artificial illumination should use an area of fire target rather than point targets, (b) night fire using the AN/PVS-4 can be conducted out to ranges of 300 m, and (c) protective mask fire during daylight can be conducted out to ranges of 300 m.

The first three experiments indicate that night fire conducted under various levels of artificial illumination was not effective in terms of the number of targets hit at 75 or 175 m. The most effective method of engaging targets under these conditions was achieved using through-the-sight aiming with the 5 mm rear aperture on the M16A2 at 75 m (pH = .314). These results are, nevertheless, well below the performance standard specified in the current ARM POI (pH = .50). It must be noted, however, that night fire is currently conducted for familiarization only and the soldiers are not evaluated according to the performance standards specified in the POI. Similarly, the results obtained for night fire using a muzzle flash simulator and a combination of artificial illumination and a muzzle flash simulator reflect the same low probability of hits at both 75 and 175 m.

Collectively, these results demonstrate the futility of requiring soldiers to shoot with 50% effectiveness using a method of target engagement (the over-the-sight pointing technique) that is most effective at ranges less than 75 m. It appears that unrealistic, and arbitrary standards have been established for the soldiers to meet in the current training schedule. The data obtained during this research effort support adoption of an area of fire target for night fire under artificial illumination. A detailed outline of the lesson plan, the proposed area of fire, and the performance standards for this POI is given in Martere, Hunt, Parish, and Lucariello (in preparation).

The concept of an area of fire target is particularly compatible with the use of LOMAH technology, since the proposed area of fire (8 ft wide x 5 ft high) is well within the detection capabilities of LOMAH equipment currently in use at the training base. Even if LOMAH technology was not available, this type of target could be implemented using a panel configuration with hit sensors located on the panel to count number of hits. The standards specified by Martere et al. (in preparation) were based on the shot location data obtained during this research effort. The standards require the soldier to obtain 75% area hits at 75 m when firing tracer ammunition in conjunction with ball ammunition, and 45% area hits at 75 m when firing ball ammunition only. Adoption of these standards would ensure that soldiers are capable of producing effective suppressive fire and, therefore, increase the probability of obtaining target hits.

In conjunction with the adoption of an area of fire target rather than point targets, two further suggestions are the use of a transitional training POI, and reorganization of the current quick fire POI. The significant correlation between daylight fire and night fire at 75 m in Experiment 3 indicates that using daylight fire during a transitional night fire POI may benefit soldiers during night fire. Similarly, if the current quick fire POI was reorganized to include engaging an area of fire target at 75 m (8 ft wide x 5 ft high) this may also benefit soldiers during night fire. The transitional training and modified quick fire POIs would allow soldiers the opportunity to establish a target/weapon relationship that enables them to achieve the appropriate percentage of area target hits. This in turn, allows them to apply the same procedure to engage the area of fire target at night. Any POI that replicates the firing procedures to be used during night fire could be expected to produce better transfer of training than a POI that is incongruous with other training.

In conclusion, if the suggested POI for night fire with artificial illumination is adopted then the percentage of effective suppressive fire and the probability of hitting targets at night would increase.

The results for night fire using the AN/PVS-4 night vision sight are important for several reasons. First, they indicate that a 25-meter zeroing procedure performed during daylight is effective as a preliminary zero for subsequent night fire. Second, they show that an AN/PVS-4 that is zeroed to a particular weapon can be used by any soldier that understands the procedures for target engagement using the night vision sight reticle. Finally, when compared with the results of Experiments 1, 2, and 3, night fire effectiveness using the AN/PVS-4 is superior to night fire under various conditions of artificial illumination (Figure 8).

The increased effectiveness of night fire using the AN/PVS-4 compared with night fire performed under varying conditions of artificial light can be attributed to the increased ability of soldiers to detect targets using a night vision sight. Similarly, there was a significant performance difference between the treatment groups in the pilot study and the test company in Experiment 4 because of the increased ability of one treatment group to detect targets more easily. Target detection for Group 1 in both companies was higher

because targets were equipped with a lighting mechanism to simulate return enemy fire, and the soldiers used the AN/PVS-4. However, soldiers in Group 2 in both companies had to rely on their ability to detect targets with only the AN/PVS-4. There are two possible explanations that account for the superior performance of Group 1 for both companies: (a) testing of both companies was performed in very poor conditions, with overcast skies and very little ambient light, and (b) soldiers were given a minimal amount of instruction on target detection techniques prior to night fire. Overall, these data clearly indicate the need for use of a night vision sight to obtain maximum effectiveness at night. In addition, the results obtained in this research effort may not reflect the true capability of the AN/PVS-4 as a night vision sight because of the unfavorable conditions in which the test was performed. There is a definite need to perform additional research under various conditions of ambient light. It is possible that the standards established for night fire using the AN/PVS-4 based on this research effort are too low because of the poor conditions in which the experiment was conducted. A possible solution to the problem of continuously changing ambient light conditions, is to standardize target detection requirements for night fire using the AN/PVS-4 by equipping all targets with the lighting mechanism to simulate return enemy fire.

The use of the AN/PVS-4 night vision sight is clearly a more effective way of engaging point targets at night. It allows a soldier to engage a target with the same precision he/she engages a target during daylight. In contrast, night fire with artificial illumination requires the soldier to engage targets with an over-the-sight pointing technique that is both imprecise and ineffective.

The findings for protective mask fire during daylight indicate that soldiers can be expected to engage targets out to 300 m. The significant correlation between BRM qualification scores and protective mask fire scores show a moderate positive relationship between the two methods of fire. This finding is important because it suggests reasonable predictions of protective mask fire scores can be projected based on a soldier's BRM qualification score. Secondly, the data indicate the use of graphic training aids depicting the theoretically correct sight pictures for each target range is an effective training technique. No such technique is used in the current ARM training for protective mask fire.

Current ARM training for protective mask fire is suitable for initial familiarization training; however, it is inadequate in teaching soldiers about effects of rifle cant on changes in bullet trajectory at longer ranges. In addition, current training does not allow soldiers, who wear glasses and require inserts for their protective masks, to participate in protective mask fire. For maximum effectiveness, protective mask fire must require soldiers to understand changes in trajectory associated with rifle cant for engagement of long range targets, and ensure all soldiers are trained in this skill. In addition, since protective mask fire represents a critical ARM skill it is suggested that performance standards be adopted for this POI.

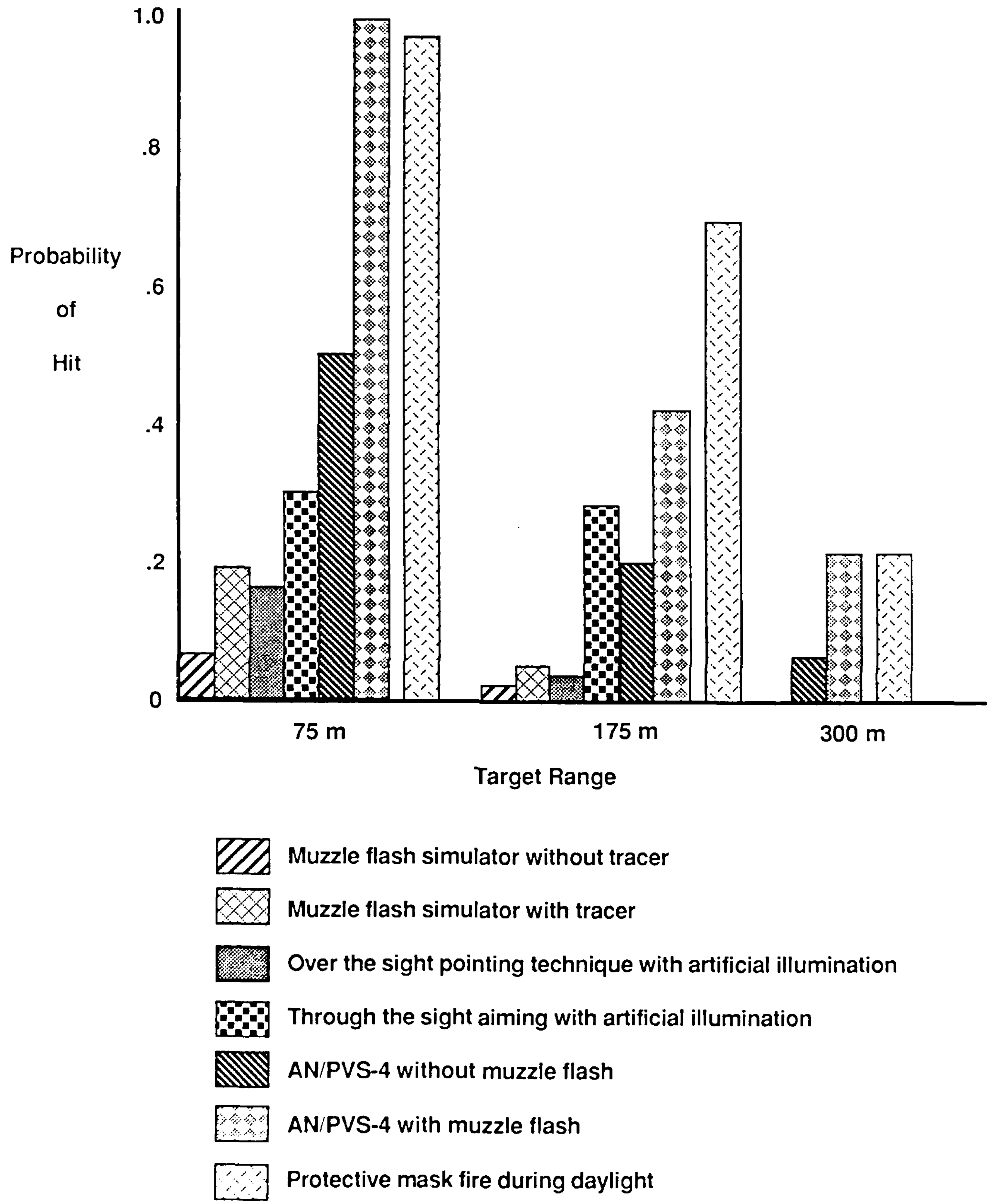

Figure 8. Summary of the results for ARM training programs for night fire & protective mask fire.

Based on the results of this research effort, the utility of providing suggested aiming points to soldiers appears valid for long range targets. However, this training technique does not represent a panacea for successful target engagement while wearing a protective mask. Differences in individual perception indicate that soldiers will have to adjust their specific aiming points for each target range (see FC 23-11, p. 23-3). This technique would, on the other hand, eliminate trial and error estimation in establishing the correct aiming points at different ranges and, therefore, would facilitate training. A detailed outline of the POI and the performance standards suggested for this course of fire are outlined in Martere et al. (in preparation). The performance standards for the course of fire outlined in this research effort are specified in terms of hit probability for each target range (pH = .8 at 75 m, pH = .5 at 175 m, pH = .2 at 300 m), and are based on the findings reported in Experiment 5 of this report.

Overall, the findings for this research effort provide evidence that night fire and protective mask fire can be improved with a combination of a modified POI and reallocation of existing resources. The three recommendations are all supported by the findings presented in this report. These recommendations require minimal reallocation of existing resources present in the training base and represent a quantifiable means of evaluating soldier performance in these critical ARM skills.

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APPENDIX A

DESCRIPTIVE STATISTICS AND ANALYSIS OF VARIANCE TABLES FOR EXPERIMENTS 1-5

Experiment 1: Night Fire with a Muzzle Flash Simulator

Group	Target Range	No. of Cases	Targets Hit: Mean	Targets Hit: Standard Deviation
Baseline	75 m	82	.88	1.82
Test (1)	75 m	25	1.00	1.89
Test (2)	75 m	25	2.96	2.26
Baseline	175 m	82	.28	.59
Test (1)	175 m	25	.16	1.37
Test (2)	175 m	25	.52	.71

Experiment 2: Night Fire with Artificial Illumination

Group	Target Range	No. of Cases	Targets Hit: Mean	Targets Hit: Standard Deviation
Baseline	75 m	51	2.51	3.21
Over-the-sight	75 m	17	2.35	3.02
Through-the-sight	75 m	17	4.71	4.54
Baseline	175 m	51	.67	1.24
Over-the-sight	175 m	17	.29	.59
Through-the-sight	175 m	17	4.29	3.62

Experiment 3: Night Fire with Artificial Illumination
and a Muzzle Flash Simulator

Task	Target Range	No. of Cases	Targets Hit: Mean	Targets Hit: Standard Deviation
Group 1				
Daylight iteration	75 m	20	2.45	2.33
1st night iteration	75 m	20	1.30	1.66
2nd night iteration	75 m	20	1.25	1.45
Daylight iteration	175 m	20	1.40	1.90
1st night iteration	175 m	20	.20	.52
2nd night iteration	175 m	20	.15	.37
Group 2				
Daylight iteration	75 m	20	3.30	2.18
1st night iteration	75 m	20	2.15	2.81
2nd night iteration	75 m	20	1.55	1.96
Daylight iteration	175 m	20	.70	.92
1st night iteration	175 m	20	.20	.70
2nd night iteration	175 m	20	.30	.66

Experiment 4: Night Fire using the AN/PVS-4 Night Vision Sight

Group	Target Range	No. of Cases	Targets Hit	
			Mean	Standard Deviation
Baseline Day	75 m	24*	7.42	3.40
Baseline Night with Muzzle Flash	75 m	21	8.19	2.29
Baseline Night w/o Muzzle Flash	75 m	21	4.19	4.51
Test with Muzzle Flash	75 m	20	9.55	.94
Test without Muzzle Flash	75 m	20	4.90	3.96
Baseline Day	175 m	24*	3.41	3.12
Baseline Night with Muzzle Flash	175 m	21	4.76	3.51
Baseline Night w/o Muzzle Flash	175 m	21	1.38	2.56
Test with Muzzle Flash	175 m	20	4.35	3.20
Test without Muzzle Flash	175 m	20	2.05	2.04
Baseline Day	300 m	24*	.79	1.32
Baseline Night with Muzzle Flash	300 m	21	2.14	2.97
Baseline Night w/o Muzzle Flash	300 m	21	.57	.91
Test with Muzzle Flash	300 m	20	2.05	2.33
Test without Muzzle Flash	300 m	20	.60	1.14

*18 soldiers were not tested due to time constraints.

Experiment 5: Protective Mask Fire

Group	Target Range	No. of Cases	Targets Hit: Mean	Targets Hit: Standard Deviation
Baseline Day	75 m	40	7.95	2.61
Test (1)	75 m	20	9.15	1.27
Test (2)	75 m	20	9.40	.88
Test (3)	75 m	20	9.60	.68
Baseline Day	175 m	40	5.65	3.05
Test (1)	175 m	20	5.25	2.24
Test (2)	175 m	20	7.55	1.85
Test (3)	175 m	20	7.25	3.06
Baseline Day	300 m	40	2.08	2.12
Test (1)	300 m	20	3.00	2.94
Test (2)	300 m	20	2.15	1.87
Test (3)	300 m	20	2.15	2.91

TITLE EXPERIMENT 1 - NIGHT FIRE WITH MUZZLE FLASH SIMULATOR
ANOVR ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE	SUMS OF SQUARES	MEAN SQUARES	DF	F RATIO	PROB. IF ASUM. MET	PROB. WITH CONSERVATIVE DF ADJUSTMENT	PROB. WITH DF*LAMBDA HAT ADJUSTMENT
*****	********	********	**	*******	*****	************	************
BETWEEN SUBJECTS							
A	33.64000	33.64000	1	14.189	.000		
ERROR	113.8000	2.370833	48				
WITHIN SUBJECTS							
J	67.24000	67.24000	1	29.140	.000		
						.000 1 48	
							.000 1 48
AJ	16.00000	16.00000	1	6.934	.011		
						.011 1 48	
							.011 1 48
ERROR	110.7600	2.307500	48				

CORRECTED TOTAL SUM OF SQUARES = 341.4400
UNCORRECTED TOTAL SUM OF SQUARES= 476.0000
FOLLOWING MS'S MAY BE NEEDED IF HAVE SIGNIFICANT INTERACTIONS
MS(ERROR) FOR SIMPLE EFFECTS OF BETWEEN SUBJECTS FACTORS AT LEVELS OF J = 2.339167,SATTERTHWAITE(1946) DF = 95

Note: In the above analysis of variance summary table, the nomenclature is as follows:
A = Group
J = Target Range
AJ = Group x Target Range interaction

TITLE EXPERIMENT 2 - NIGHT FIRE WITH ARTIFICIAL ILLUMINATION
ANOVR ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE	SUMS OF SQUARES	MEAN SQUARES	DF	F RATIO	PROB. IF ASUM. MET	PROB. WITH CONSERVATIVE DF ADJUSTMENT	PROB. WITH DF*LAMBDA HAT ADJUSTMENT
*****	********	********	**	*******	*****	*************	*************
BETWEEN SUBJECTS							
A	171.5294	171.5294	1	19.678	.000		
ERROR	278.9412	8.716912	32				
WITHIN SUBJECTS							
J	25.94118	25.94118	1	2.017	.165		
						.165 1 32	
							.165 1 32
AJ	11.52941	11.52941	1	.897	.351		
						.351 1 32	
							.351 1 32
ERROR	411.5294	12.86029	32				

CORRECTED TOTAL SUM OF SQUARES = 899.4706
UNCORRECTED TOTAL SUM OF SQUARES= 1476.000
FOLLOWING MS'S MAY BE NEEDED IF HAVE SIGNIFICANT INTERACTIONS
MS(ERROR) FOR SIMPLE EFFECTS OF BETWEEN SUBJECTS FACTORS AT LEVELS OF J = 10.78860, SATTERTHWAITE(1946) DF = 61

Note: In the above analysis of variance summary table, the nomenclature is as follows:
A = Group
J = Target Range
AJ = Group x Target Range interaction

TITLE EXPERIMENT 3 - NIGHT FIRE WITH ARTIFICIAL ILLUMINATION AND A MUZZLE FLASH SUPPRESSOR

ANOVR ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE	SUMS OF SQUARES	MEAN SQUARES	DF	F RATIO	PROB. IF ASUM. MET	PROB. WITH CONSERVATIVE DF ADJUSTMENT			PROB. WITH DF*LAMBDA HAT ADJUSTMENT
*****	********	********	**	*******	*****	*************			*************
BETWEEN SUBJECTS									
A	3.504167	3.504167	1	.858	.360				
ERROR	155.1583	4.083114	38						
WITHIN SUBJECTS									
J	62.53333	31.26667	2	11.907	.000				
						.001	1	38	
AJ	1.233333	.6166667	2	.235	.791				
						.631	1	38	
ERROR	199.5667	2.625877	76						
K	136.5042	136.5042	1	41.667	.000				
						.000	1	38	
AK	10.83750	10.83750	1	3.308	.077				
						.077	1	38	
ERROR	124.4917	3.276096	38						
JK	4.233333	2.116667	2	1.153	.321				
						.290	1	38	
AJK	4.900000	2.450000	2	1.334	.269				
						.255	1	38	
ERROR	139.5333	1.835965	76						

CORRECTED TOTAL SUM OF SQUARES = 842.4958
UNCORRECTED TOTAL SUM OF SQUARES= 1215.000
FOLLOWING MS'S MAY BE NEEDED IF HAVE SIGNIFICANT INTERACTIONS
MS(ERROR) FOR SIMPLE EFFECTS OF BETWEEN SUBJECTS FACTORS AT LEVELS OF J = 3.111623, SATTERTHWAITE(1946) DF = 108
MS(ERROR) FOR SIMPLE EFFECTS OF BETWEEN SUBJECTS FACTORS AT LEVELS OF K = 3.679605, SATTERTHWAITE(1946) DF = 75
MS(ERROR) FOR SIMPLE EFFECTS OF BETWEEN SUBJECTS FACTORS AT LEVELS OF JK = 2.713816, SATTERTHWAITE(1946) DF = 163
FOR SIMPLE EFFECTS OF J AT K MS(ERROR) = 2.230921; SATTERTHWAITE DF = 147
FOR SIMPLE EFFECTS OF K AT J MS(ERROR)= 2.316009; SATTERTHWAITE DF = 104

Note: In the above analysis of variance summary table, the nomenclature is as follows:
A = Group
J = Firing Iteration
AJ = Group x Firing Iteration interaction
K = Target Range
AK = Group x Target Range interaction
JK = Firing Iteration x Target Range interaction
AJK = Group x Firing Iteration x Target Range interaction

TITLE EXPERIMENT 4 (PILOT) - NIGHT FIRE USING THE AN/PVS-4 NIGHT VISION SIGHT

ANOVR ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE	SUMS OF SQUARES	MEAN SQUARES	DF	F RATIO	PROB. IF ASUM. MET	PROB. WITH CONSERVATIVE DF ADJUSTMENT	PROB. WITH DF*LAMBDA HAT ADJUSTMENT
*****	********	********	**	*******	*****	*************	*************
BETWEEN SUBJECTS							
A	280.5079	280.5079	1	23.337	.000		
ERROR	480.7937	12.01984	40				
WITHIN SUBJECTS							
J	504.3968	252.1984	2	46.047	.000		
						.000 1 40	
							.000 2 68
AJ	33.44444	16.72222	2	3.053	.053		
						.088 1 40	
							.054 2 68
ERROR	438.1587	5.476984	80				

CORRECTED TOTAL SUM OF SQUARES = 1737.302

UNCORRECTED TOTAL SUM OF SQUARES= 3316.000

FOLLOWING MS'S MAY BE NEEDED IF HAVE SIGNIFICANT INTERACTIONS

MS(ERROR) FOR SIMPLE EFFECTS OF BETWEEN SUBJECTS FACTORS AT LEVELS OF J = 7.657937, SATTERTHWAITE(1946) DF = 103

Note: In the above analysis of variance summary table, the nomenclature is as follows:

A = Group

J = Target Range

AJ = Group x Target Range interaction

TITLE EXPERIMENT 4 (TEST) - NIGHT FIRE USING THE AN/PVS-4 NIGHT VISION SIGHT

ANOVR ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE	SUMS OF SQUARES	MEAN SQUARES	DF	F RATIO	PROB. IF ASUM. MET	PROB. WITH CONSERVATIVE DF ADJUSTMENT	PROB. WITH DF*LAMBDA HAT ADJUSTMENT
*****	********	********	**	*******	*****	*************	*************
BETWEEN SUBJECTS							
A	235.2000	235.2000	1	32.077	.000		
ERROR	278.6333	7.332456	38				
WITHIN SUBJECTS							
J	727.0167	363.5083	2	63.166	.000		
						.000 1 38	
							.000 2 66
AJ	54.95000	27.47500	2	4.774	.011		
						.035 1 38	
							.012 2 66
ERROR	437.3667	5.754825	76				

CORRECTED TOTAL SUM OF SQUARES = 1733.167

UNCORRECTED TOTAL SUM OF SQUARES= 3574.000

FOLLOWING MS'S MAY BE NEEDED IF HAVE SIGNIFICANT INTERACTIONS

MS(ERROR) FOR SIMPLE EFFECTS OF BETWEEN SUBJECTS FACTORS AT LEVELS OF J = 6.280702, SATTERTHWAITE(1946) DF = 112

Note: In the above analysis of variance summary table, the nomenclature is as follows:

A = Group

J = Target Range

AJ = Group x Target Range interaction

TITLE EXPERIMENT 5 - PROTECTIVE MASK FIRE

ANOVR ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE	SUMS OF SQUARES	MEAN SQUARES	DF	F RATIO	PROB. IF ASUM. MET	PROB. WITH CONSERVATIVE DF ADJUSTMENT	PROB. WITH DF*LAMBDA HAT ADJUSTMENT
*****	********	********	**	*******	*****	*************	*************
BETWEEN SUBJECTS							
A	12.13333	6.066667	2	.861	.428		
ERROR	401.5333	7.044444	57				
WITHIN SUBJECTS							
J	1473.100	736.5500	2	219.712	.000		
						.000 1 57	
							.000 2 113
AJ	62.06667	15.51667	4	4.629	.002		
						.014 2 57	
							.002 4 113
ERROR	382.1667	3.352339	114				

CORRECTED TOTAL SUM OF SQUARES = 2331.000

UNCORRECTED TOTAL SUM OF SQUARES= 9176.000

FOLLOWING MS'S MAY BE NEEDED IF HAVE SIGNIFICANT INTERACTIONS

MS(ERROR) FOR SIMPLE EFFECTS OF BETWEEN SUBJECTS FACTORS AT LEVELS OF J = 4.583041, SATTERTHWAITE(1946) DF = 149

Note: In the above analysis of variance summary table, the nomenclature is as follows:

A = Group

J = Target Range

AJ = Group x Target Range interaction